Developing Updated Activity Inputs for Nonroad Equipment

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Background

- **Definition: "Land-based Nonroad Equipment"**
  - Not stationary (moves within a 12 month period)
  - Not an on-road vehicle (car or truck)
  - Not an aircraft
  - Not a locomotive
  - Not a commercial marine vessel
- **Nonroad Equipment contribute to mobile-source Inventory**
- **Diesel equipment important for NOx, PM inventories**
- **Current Inventory model is dated**
  - NONROAD incorporated into MOVES platform in 2014
  - Key default inputs are dated
    - 15 – 20 years old
  - Model structure is dated
    - Base years 1996-2000

Estimating Exhaust Emissions Inventory

$$I = [(P \times L) \times A \times N] \times E$$

I = Inventory (g, kg, Mg, U.S. tons),
P = Mean rated power (hp, kW)
L = Load factor (fraction of rated power, %)
A = Activity (hr/yr)
N = Population (units)
E = Emission rate (g/hp-hr, g/kW-hr)

$$\text{g/yr} = [(\text{hp} \times \%) \times \text{hr/yr} \times n] \times \text{g/hp-hr}$$

Scope

- **Goal: Evaluate equipment activity**
- **For selected diesel equipment types**
  - Wheel loaders
  - Skid-steer loaders
  - Excavators
  - Agricultural Tractors
  - Combines

Equipment Activity

- **Definition:** Hours of use
- **Temporal scale:** Annual
- **Geographic scale:** National & Regional
- **Current modeling assumptions:**
  - Varies by equipment type (different for loaders, excavators, tractors, etc.)
  - Is the same everywhere
  - Is the same always
    - Does not change in future
    - Does not change as equipment ages
  - Is the same for small and large equipment
- **Reviewing these assumptions using new data**

Estimating Activity

- **New data source: Auction-house Records**
  - Hour-meter readings at time of sale
  - Place of residence at time of sale
    - Enables analysis by region
  - Supplemented power ratings
    - To enable analysis by size
- **Gives life-time average at age of reading**
- **Estimated variances by empirical bootstrap**
  - Simple random sampling with replacement
  - Thousands of replications

$$A = \frac{\text{hour-meter}}{\text{CY}_{\text{sale}} - \text{MY}} = \frac{\text{hr}}{\text{years}}$$

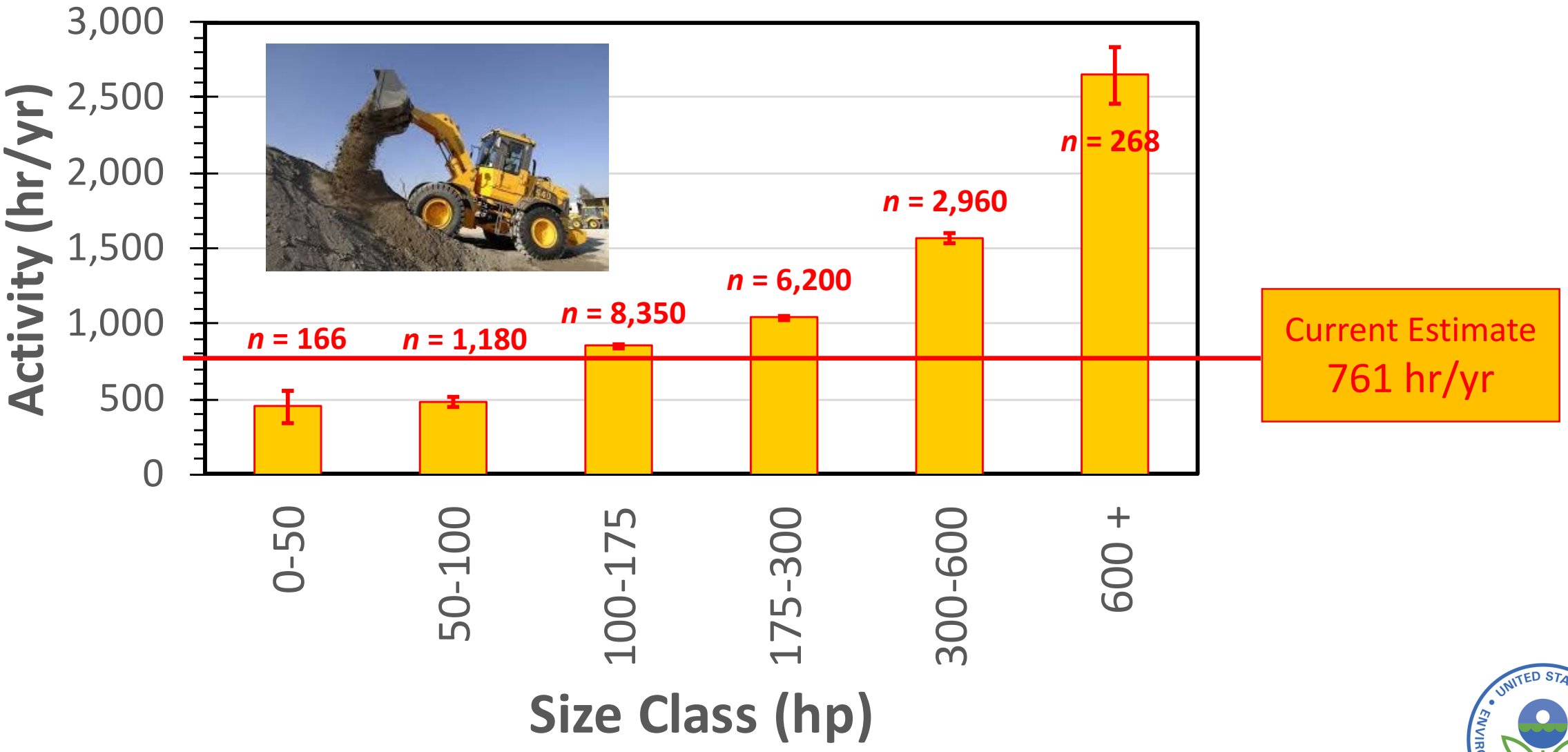
Size Classes (rated power, hp)

- **Size classes follow the emissions standards**
  - For nonroad diesel engines
  - For Tier 1 – Tier 3
- **0-50 hp**
- **50-100 hp**
- **100-175 hp**
- **175-300 hp**
- **300-600 hp**
- **600+ hp**
- **Sample sizes are very small for smallest and largest engines**

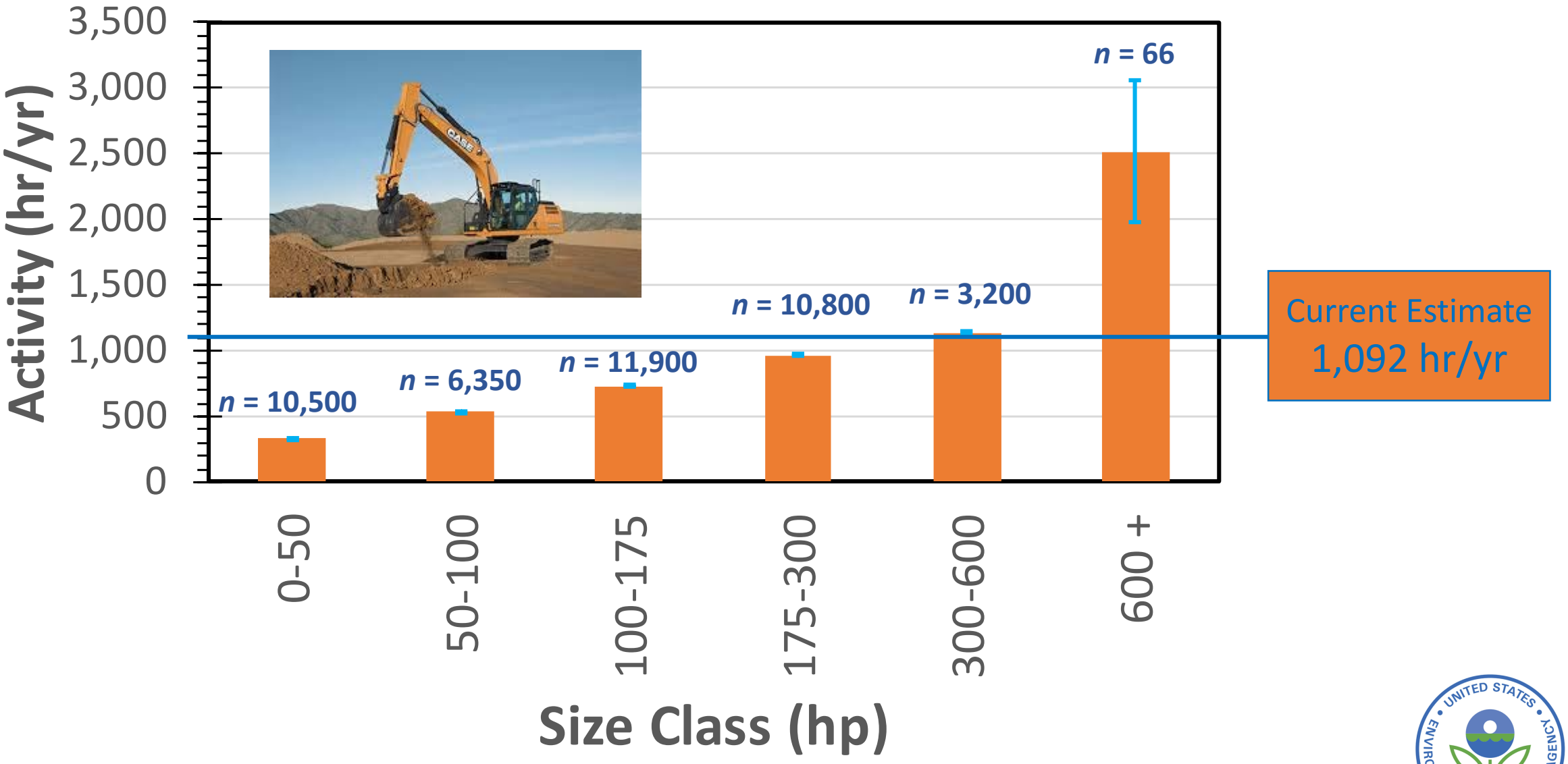
Annual Activity by Size Class

At National Scale

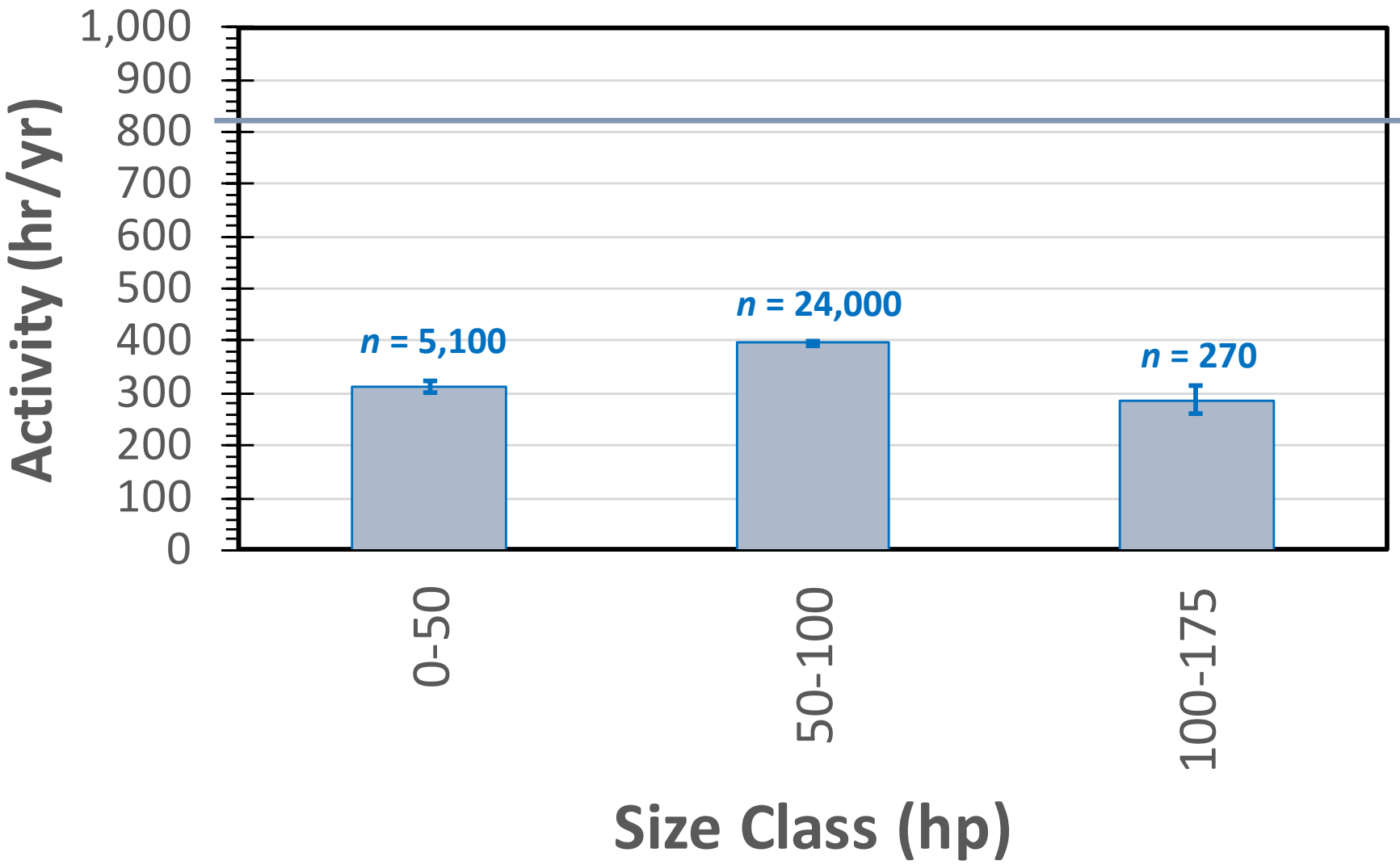
Activity by Size Class: Wheel Loaders



Activity by Size Class: Excavators

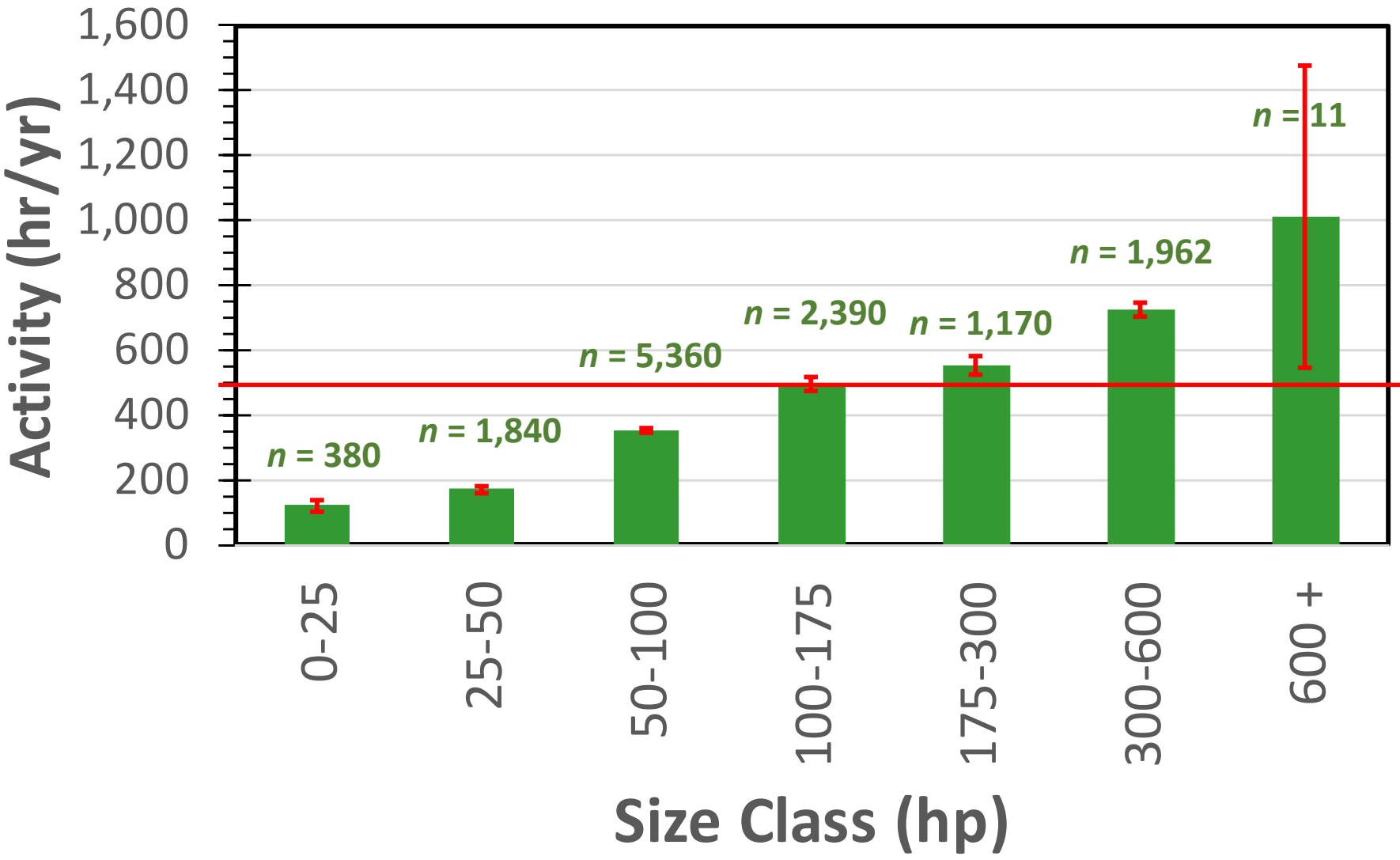


Activity by Size Class: Skid-steer Loaders



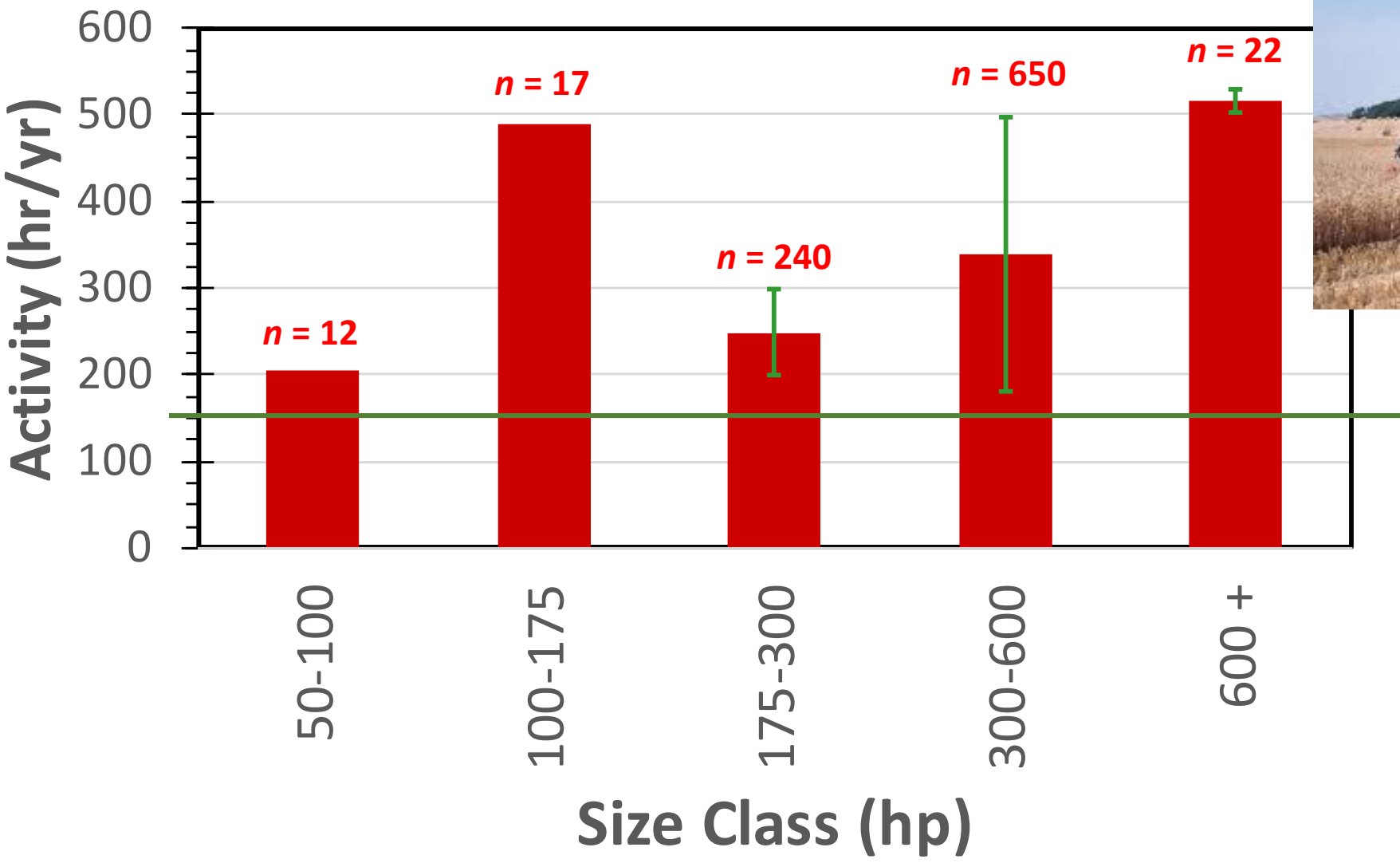
Current Estimate
818 hr/yr

Activity by Size: Agricultural Tractors



Current Value:
475 hr/yr

Activity by Size: Combines

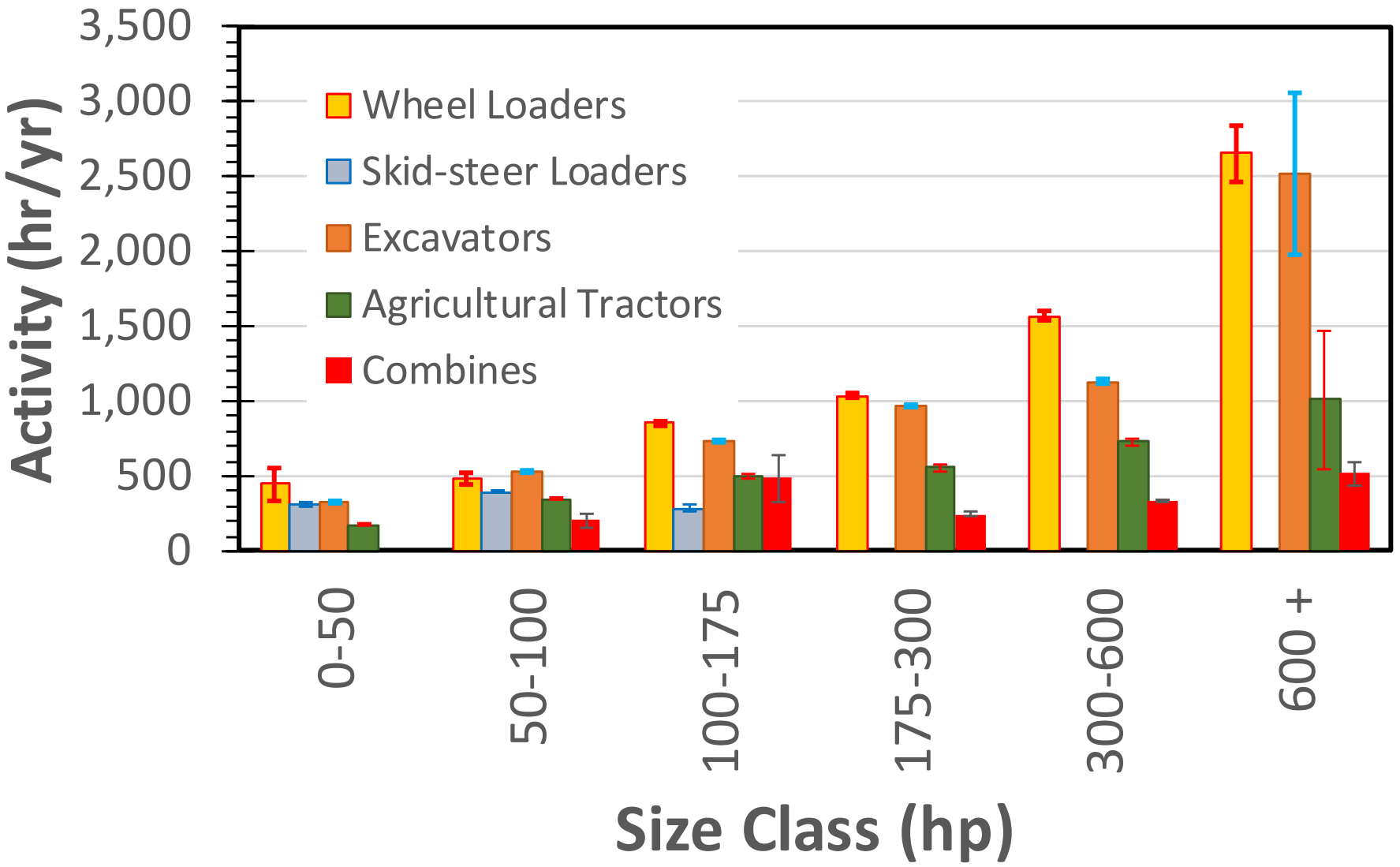


Current Estimate:
150 hr/yr

Annual Activity by Equipment Type and Size

At National Scale

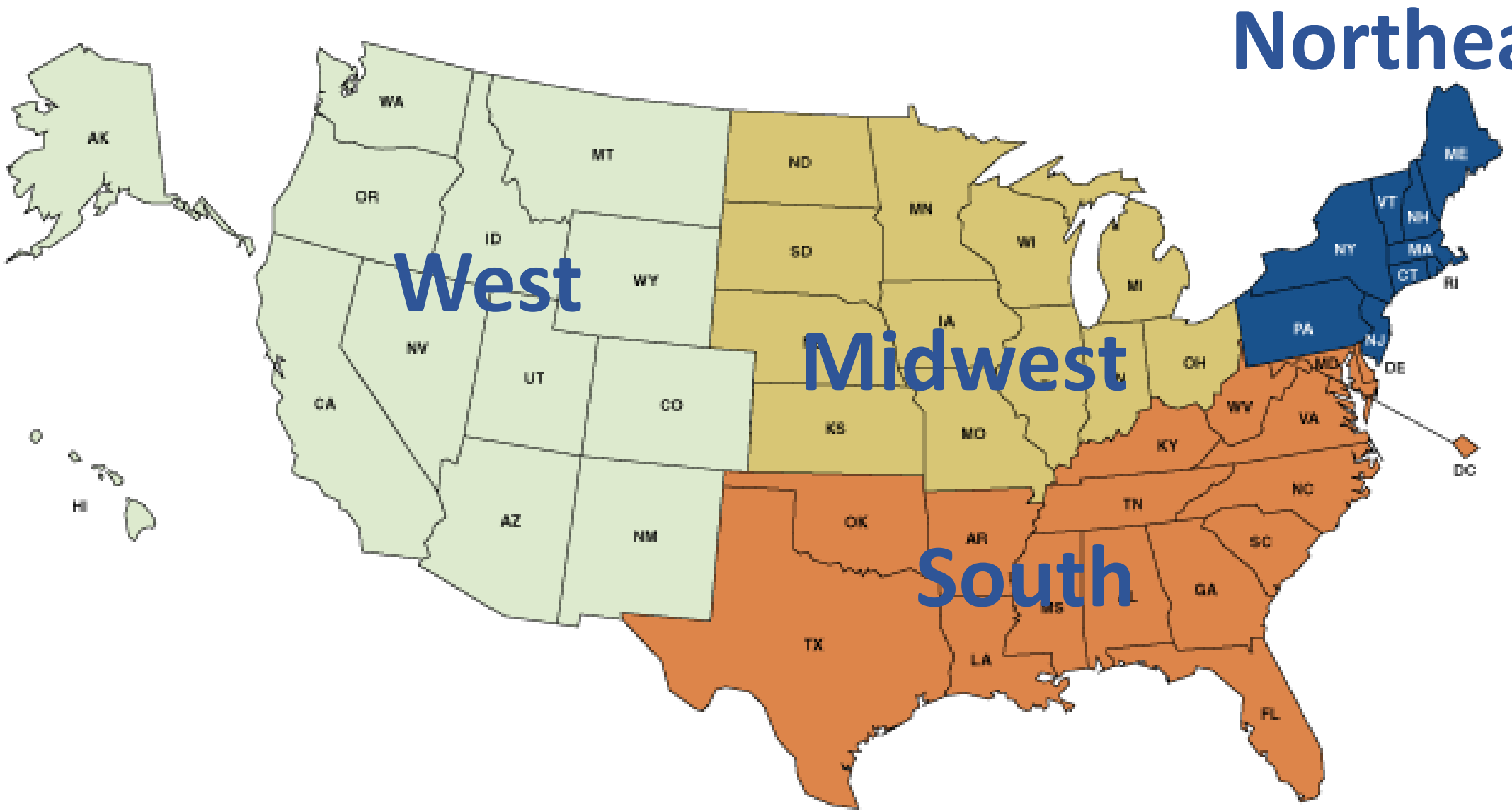
Five Equipment Types by Size Class



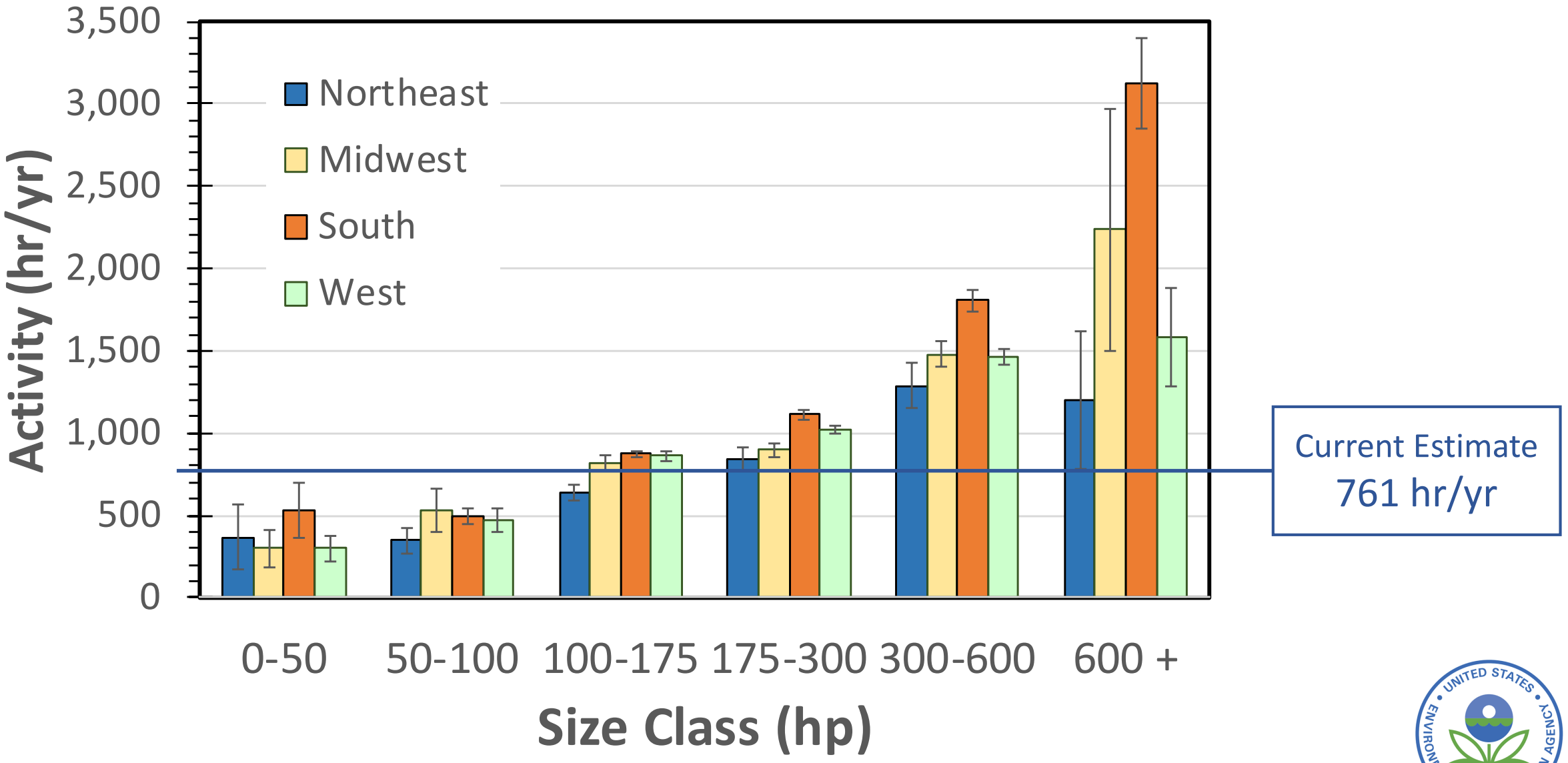
Annual Activity by Size Class

At Regional Scale

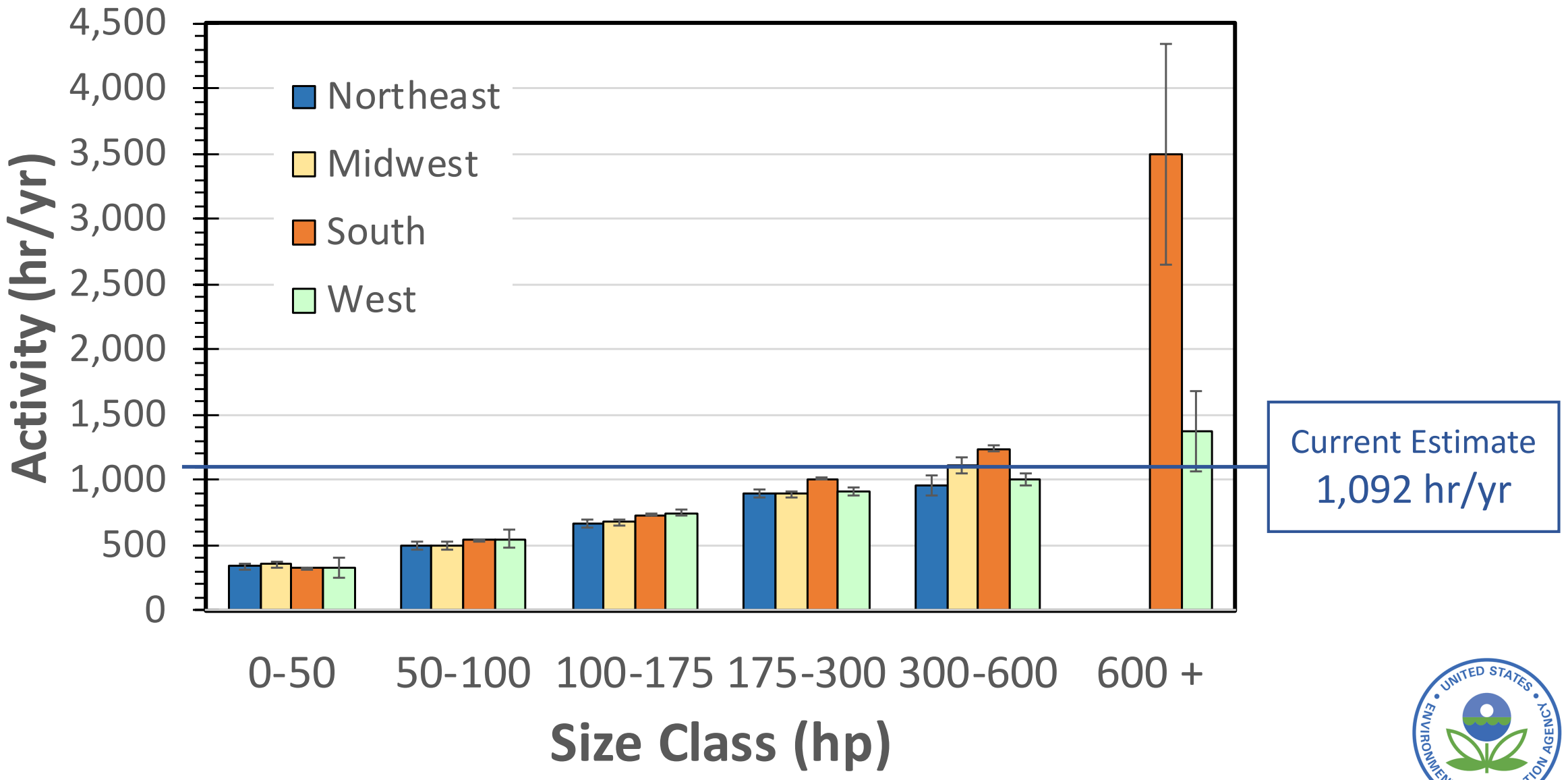
Census Regions



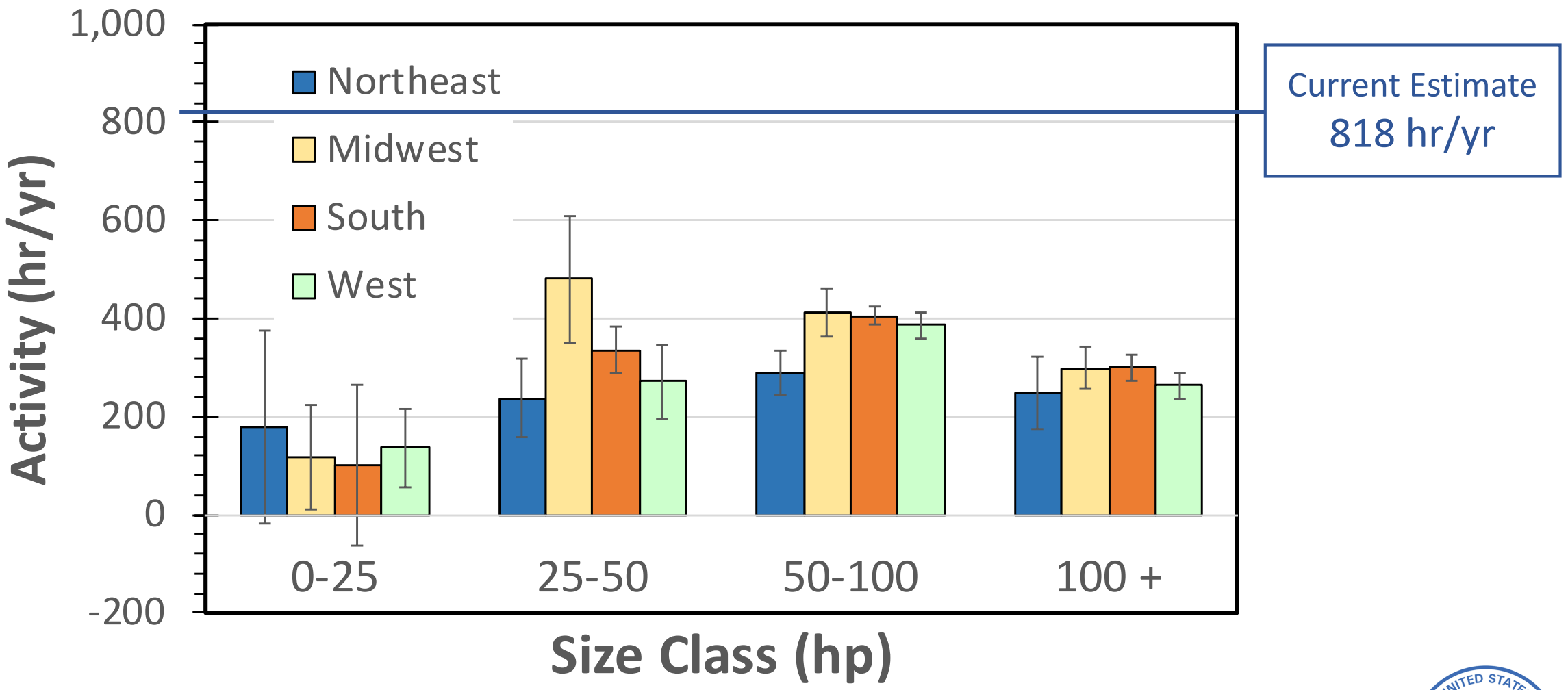
Wheel Loaders



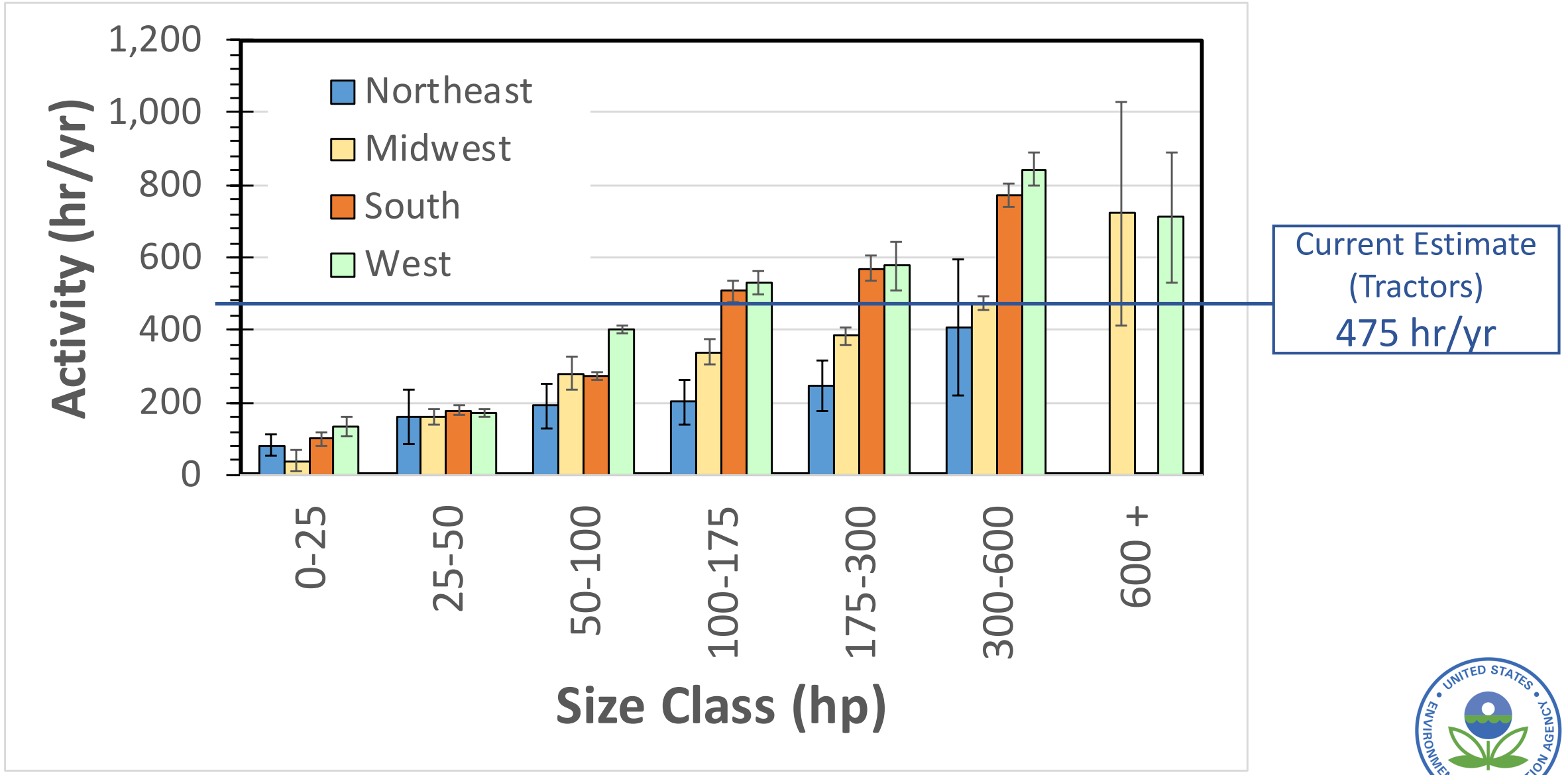
Excavators


4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Activity (hr/yr)
Northeast
Midwest
South
West
Current Estimate
1,092 hr/yr
0-50
50-100
100-175
175-300
300-600
600 +
Size Class (hp)

Skid-steer Loaders



Agricultural Tractors and Combines



Conclusions

- **Activity varies by Equipment Type**
  - Wheel Loaders > Excavators > Skid-steer Loaders
  - Ag Tractors > Combines
- **Activity increases by Equipment Size**
  - For types with wide variation in size
  - MOVES-Nonroad tends to:
    - Overestimate activity for smallest diesel equipment
    - Underestimate activity for largest diesel equipment
- **Activity varies by region**
  - To some degree
  - Likely related to climate (e.g., length of working, growing seasons)
  - Has implications for allocation
- **What are implications for inventory?**
  - Depends on changes in total kW-hr
    - Also re-estimating populations
  - Too soon to call

Next Steps

- **Estimate Activity for other (Diesel) equipment types**
  - Using recently acquired auction-house data
  - 60-80 equipment types
- **Estimate Activity by Age**
  - Data becoming available
- **Estimate Other inputs**
  - Mean rated power (*P*)
    - Account for trends over time?
  - Load factor (duty cycle) (*L*)
    - Draw on data from portable measurement systems and telematics
  - Populations (*N*)
    - Sales and scrappage
- **Develop Inputs for new inventory model**